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George C. Marshall Space Flight Center
Marshall Space Flight Center, Alabama 35812

ORGANIZATIONAL INSTRUCTION

RELIABILITY ANALYSIS

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DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline		11/20/97	
Revision	A	11/22/99	Changes made to reflect new organization code changes and/or Changes made to reflect new directives renumbering scheme and to incorporate the corrective action for closure of NCR 266. Change completes OWI to OI conversion.
Revision	B	07/01/01	Changed OPR and OPR Designee. Added Quality Records table.
Revision	C	9/09/02	Format and numbering change to implement requirements of QS-A-001 rev F.
Revision	D	10/21/03	Added applicable and reference documents. Added additional Reliability Analysis details.

Reliability Analysis

1. PURPOSE, SCOPE, APPLICABILITY

1.1 Purpose

The purpose of this Organizational Instruction (OI) is to provide procedures on various analysis tools for assessing system reliability during the different program phases.

1.2 Scope

This OI describes the process of evaluating reliability during the life cycle of a system using probabilistic risk assessment models, reliability predictions, Failure Modes And Effects Analysis/Critical Items Lists (FMEA/CILs), reliability assessment, reliability trade studies and sensitivity analyses, demonstrated reliability models, trend analysis, and reliability growth models.

1.3 Applicability

This OI is applicable to all S&MA personnel supporting MSFC programs and projects that require or specify reliability requirements.

2. DOCUMENTS (Applicable and/or Referenced)

2.1 Applicable Documents

NPD 8720.1	NASA Reliability and Maintainability (R&M) Program Policy
NASA-STD-8729.1	Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program
MPG 8730.4	Statistical Techniques

2.2. Reference Documents

MIL-HDBK-189	Reliability Growth Management
QS-R-001	Failure Mode and Effects Analysis and Critical Items List

QS-R-009 Reliability Prediction
Handbook of Reliability Engineering and Management, W.G. Ireson and C.F. Coombs Jr., 1988.

Probabilistic Risk Assessment and Management for Engineers and Scientists, H. Kumamoto and E.J. Henley, 1996.

Reliability Toolkit: A Practical Guide for Commercial Products and Military Systems Under Acquisition Reform, Reliability Analysis Center

3. DEFINITIONS

All definitions applicable to this OI are addressed in NASA-STD-8729.1

4. INSTRUCTIONS

An example of a typical Reliability analysis process is shown in Figure 1. The following sections provide an overview of different types of reliability analyses (probabilistic risk assessment, demonstrated reliability, trend analysis, and reliability growth). The analyses should be updated as appropriate (i.e., with design changes or design evolution).

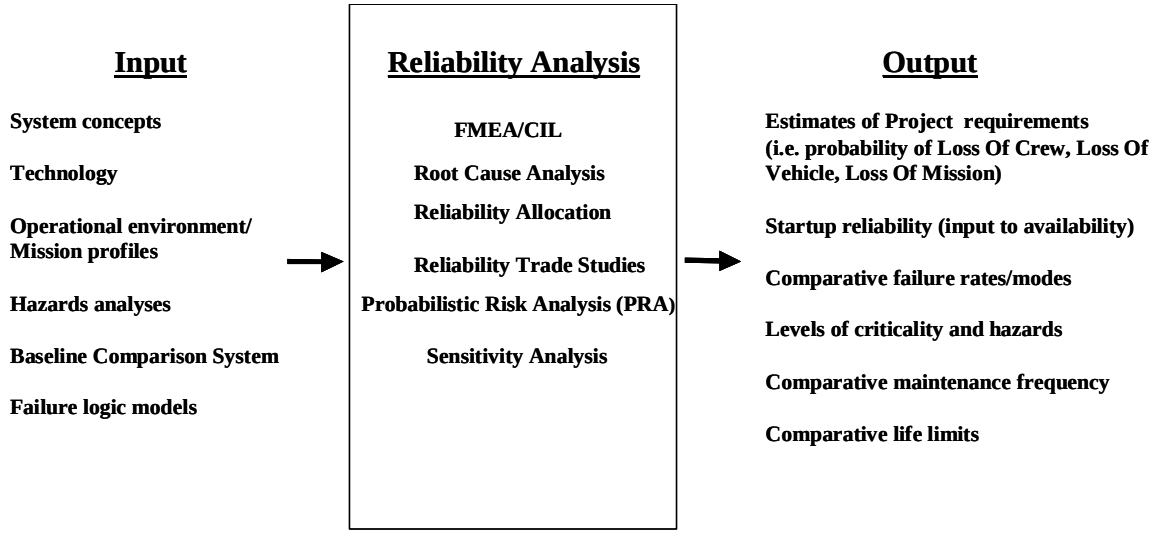


Figure 1. Reliability Analysis Flow Process

4.1 Probabilistic Risk Assessment

A Probabilistic Risk Assessment (PRA) is performed to calculate risk, perform sensitivity analysis, and conduct trade studies at various system levels. The steps below define the procedure for developing a probabilistic risk assessment model and are referenced in the Flow Diagram 4.1 in Section 11.

Steps	Action
4.1.1	Define the system for which the probabilistic risk assessment is applicable and the baseline design assumptions for which the reliability analysis is anchored. Also, identify reliability design criteria. Describe analysis approach and expected tools to be utilized.
4.1.2	Collect/screen and analyze data.
4.1.3	Identify initiating events and underlying assumptions.
4.1.4	Construct event sequence diagrams (ESDs) for each initiating event.
4.1.5	Determine the uncertainty distribution for each initiating and pivotal events and rationale for selection.
4.1.6	Aggregate the uncertainty distributions in 4.1.5.
4.1.7	Aggregate all ESDs results to determine the risk for failure mode/component/system/ subsystem.
4.1.8	Report results and identify potential updates.

4.2 Reliability Prediction

When a limited amount of data are available, reliability predictions can be performed, in lieu of PRA, to calculate risk, perform sensitivity analysis, and conduct trade studies. Refer

to Organizational Instruction QS-R-009 for more information regarding Reliability Prediction.

4.3 Failure Modes and Effects Analysis/Critical Items List

The Failure Modes and Effects Analysis/Critical Items List (FMEA/CIL) provides a qualitative method to identify single failure points and effects and to establish and rank critical failures for purposes of potential design improvements at component and/or system level. Maximum benefit results from application early in the design process. Refer to Organizational Instruction QS-R-001 for more information regarding FMEA/CIL.

4.4 Demonstrated Reliability Determination

Reliability demonstration provides a quantitative estimate of reliability based on objective data. For maximum benefit, it should be focused on appropriately tailoring test inputs to produce the data needed to anchor reliability analyses. The steps below define the procedure for performing reliability demonstration and are referenced in the Flow Diagram 4.2 in Section 11.

Steps	Action
4.4.1	Define the item to be considered for reliability demonstration. Define reliability test objective, parameters, and preferred data format.
4.4.2	Collect applicable objective data (e.g. actual test/flight data).
4.4.3	Identify the appropriate reliability model (e.g. binomial, weibull, etc.) and methods for selection. Identify tools used.
4.4.4	Determine the demonstrated reliability prediction for the item under consideration.
4.4.5	Publish technical results and recommendations. Update when needed.

4.5 Trend Analysis

Trend analysis is a tool used in conjunction with reliability analysis. The steps below define the procedure for performing trending analysis and are referenced in the Flow Diagram 4.3 contained in Section 11.

Steps	Action
4.5.1	Identify the item/parameter to be trended.
4.5.2	Identify and collect applicable data.
4.5.3	Identify appropriate trending technique.
4.5.4	Perform trend analysis.
4.5.5	Interpret trend data and identify trends and underlying assumptions.
4.5.6	Publish technical results and recommendations.

4.6 Reliability Growth

Reliability growth is the positive improvement in reliability due to changes in product design or the manufacturing process. Reliability growth studies usually have two objectives. The first objective is the determination of demonstrated reliability at some point in time. The second objective provides information about growth patterns that might be useful to support decisions regarding the future of the program. This process should provide flexibility to allow continuous feedback into the design process; such as identifying process benchmarks to check actuals against predictions, so that adjustments can be made that will allow a return to schedule with minimal program impact. The steps below define the procedure for performing reliability growth analysis and are referenced in the Flow Diagram in Section 11.

Steps	Action
4.6.1	Identify the item to be considered for reliability growth analysis.
4.6.2	Establish a system by which test/flight data are collected and maintained.

4.6.3 Determine the appropriate reliability growth model (example: Army Materials System Activity Analysis (AMSAA)) Identify reliability test parameters to be tracked with design evolution.

4.6.4 Perform reliability growth analysis to track item reliability over time and provide roadmaps to address expected design deltas.

4.6.5 Assess reliability growth analysis results to determine reliability trend.

4.6.6 Establish dynamic reliability growth model to accommodate potential design changes.

5. NOTES

5.1 Directive Replacement. This Directive replaces S&MA-CR10-R-Y-010, Reliability Analysis.

6. SAFETY PRECAUTIONS AND WARNING NOTES

None.

7. APPENDICES, DATA, REPORTS, AND FORMS

None.

8. QUALITY RECORDS

Quality Record	Repository	Period of Time
Reliability Analysis Report	Hardcopy maintained in R&M files in Building 4471 Room A105	Retain until end of program plus 3 years.

9. TOOLS, EQUIPMENT, AND MATERIALS

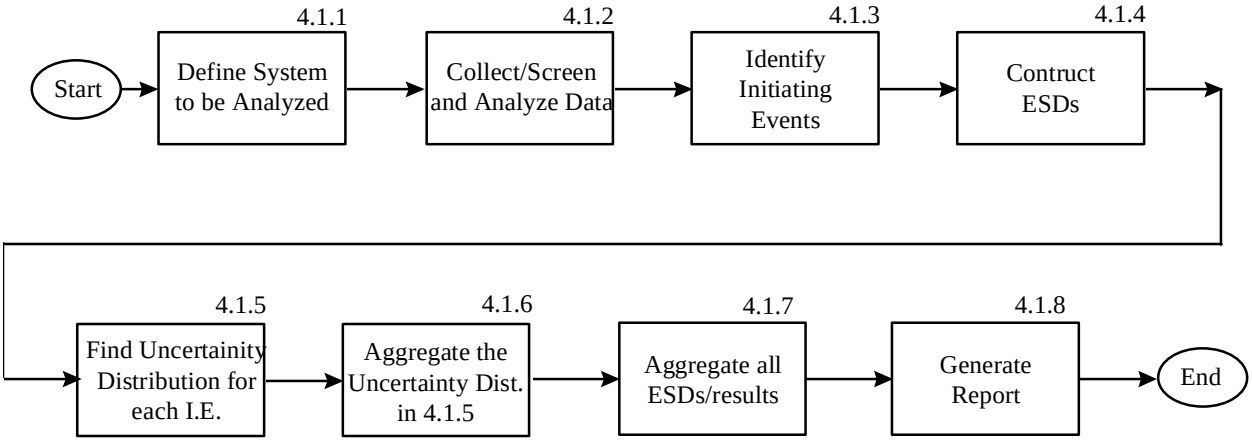
The user should define any tools, special equipment, or materials used during the reliability analysis process.

10. PERSONNEL TRAINING AND CERTIFICATION

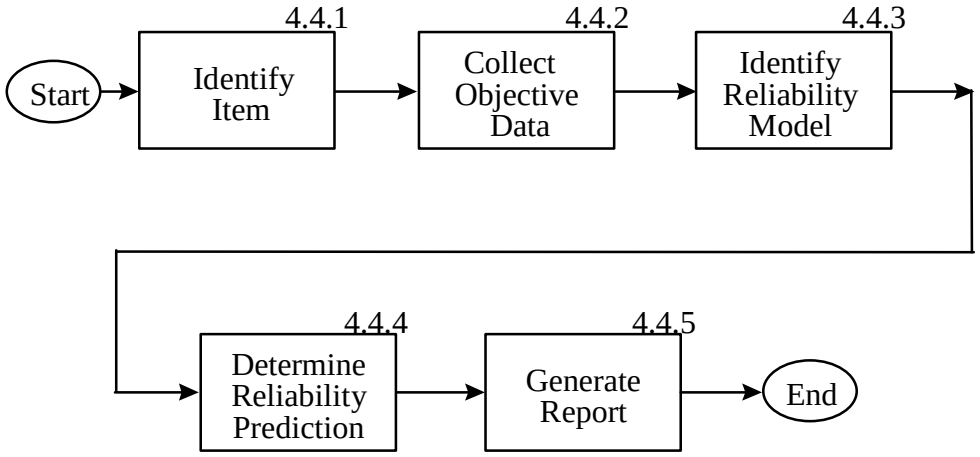
Reliability training will include reliability analysis.

11. FLOW DIAGRAM

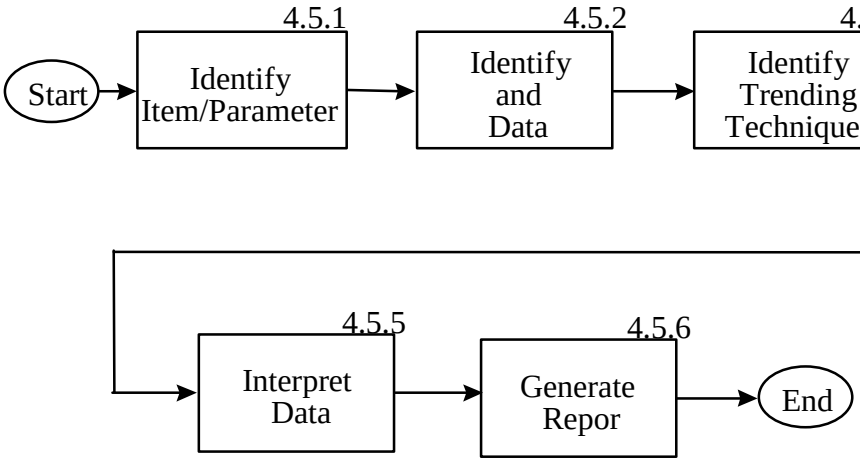
The following flow diagram represents the Reliability Analysis instructions for Probabilistic Risk Assessment outlined in Section 4.1.



The following flow diagram represents the Reliability Analysis instructions for Reliability Demonstration outlined in Section 4.4.



The following flow diagram represents the Reliability Analysis instructions for Trending Analysis outlined in Section 4.5.



The following flow diagram represents the Reliability Analysis instructions for Reliability Growth outlined in Section 4.6.